FLOOD PLAIN INFORMATION

QUABOAG RIVER

WARREN, MASSACHUSETTS

PREPARED BY THE DEPARTMENT OF THE ARMY, NEW ENGLAND DIVISION,
CORPS OF ENGINEERS, WALTHAM, MASSACHUSETTS

MARCH 1976

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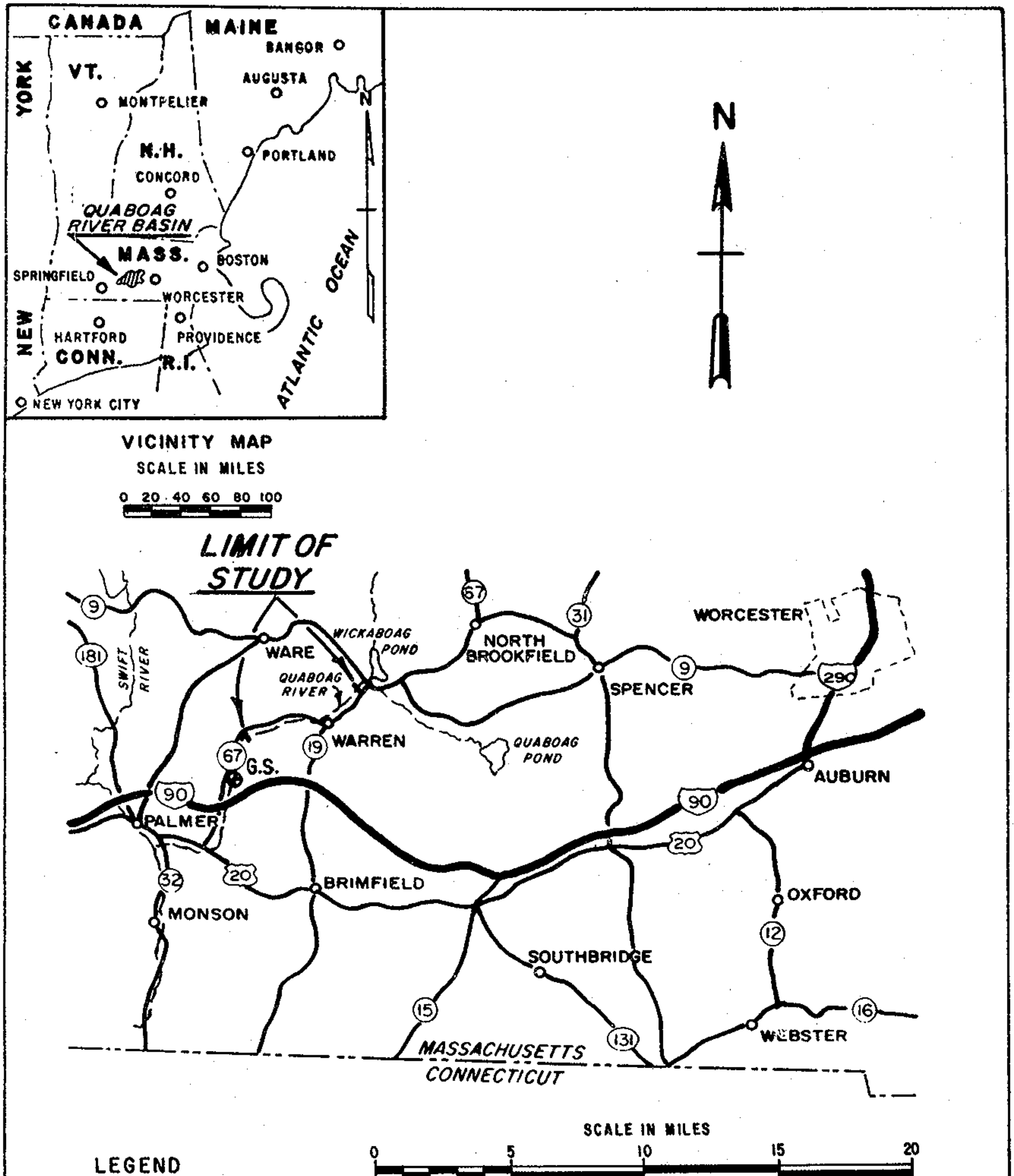


LEGEND

GAGING STATION

STATE LINE

7 U.S. HIGHWAY

41 STATE HIGHWAY

FLOOD PLAIN INFORMATION

WARREN, MASSACHUSETTS

GENERAL MAP

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
MARCH 1976

PLATE 1

PREFACE

The portions of the Town of Warren covered by this report are subject to flooding from the Quaboag River. The properties along this stream are primarily residential, commercial, and industrial and have been severely damaged by the floods of 1955, 1938, and 1936. The open spaces in the flood plains which may come under pressure for future developments are limited. Although large floods have occurred in the past, studies indicate that even larger floods are possible.

This report has been prepared because a knowledge of flood potential and flood hazards is important in land use planning and for management decisions concerning flood plain utilization. It includes a history of flooding in the community and identifies those areas that are subject to possible future floods. Special emphasis is given to these floods through maps, photographs, profiles and cross-sections. The report does not provide solutions to flood problems; however, it does furnish a suitable basis for the adoption of land use controls to guide flood plain development and thereby prevent intensification of the loss problems. It will also aid in the identification of other flood damage reduction techniques such as works to modify flooding and adjustments, including flood proofing which might be embodied in an overall Flood Plain Management (FPM) program. Other FPM program studies - those of environmental attributes and the current and future land use role of the flood plain as part of its surroundings - would also profit from this information.

At the request of the Massachusetts Water Resources Commission, this report was prepared by Tighe & Bond, Division of Sippican Consultants International, Holyoke, Massachusetts for the New England Division of the Corps of Engineers under continuing authority provided in Section 206 of the 1960 Flood Control Act, as amended.

Assistance and cooperation of the Massachusetts Department of Public Works, U.S. Geological Survey, Worcester County Engineer, U.S. Department of Agriculture, Soil Conservation Service, and private citizens in supplying useful data and photographs for the preparation of this report are appreciated.

Additional copies of this report can be obtained from the administrative offices of the Town. The New England Division of the Corps of Engineers, upon request, will provide technical assistance to planning agencies in the interpretation and use of the data presented, as well as planning guidance and further assistance, including the development of additional technical information.

BACKGROUND INFORMATION

Settlement

Warren lies on the Quaboag River about half way between Springfield and Worcester. It was less than ten (10) years after the establishment of the colony on Massachusetts Bay that a settlement was established in the Springfield area. Although thriving communities were established in the Connecticut Valley and on the coast with travel going on between the two (2) areas, there were no permanent settlements in the Central Massachusetts highlands for nearly one hundred (100) years. Attempts to establish settlements in the Worcester and Brimfield areas in about 1673 and 1701 failed. These attempts caused later settlers considerable trouble in establishing title to their holdings. There were some inhabitants in the region by 1722 because militia men were posted from Springfield to defend the Brimfield area at that time. In 1731 the General Court acted to settle the land title conflicts in the area and in 1741 the Town of Warren, then called "Western," was incorporated from parts of Brookfield, Brimfield and Palmer. In 1834 the name of the Town was changed to "Warren" in honor of General Warren, who fell at Bunker Hill.

Industry developed early in the Quaboag Valley because the river provided small mills with an adequate quantity of water with sufficient fall from dams of modest height to power the machinery of the time. In 1793 there were two (2) grist mills, a sawmill, a scythe mill, one fulling mill and a forge. In 1800 an ironworks was instituted in Warren and in 1812 powder mills were established. By 1837 two (2) woolen mills and a cotton mill were added to the local industry. In 1839 the Town had a population of 1,196.

The development of railroads in the early 19th century provided a much more convenient mode of transportation of goods than had been possible before. Since railroads demand minimum grades, the Quaboag River Valley provided an excellent route for the earliest east-west railroads. In 1839 the railroad from Boston was extended to Springfield providing fast, convenient transportation for products from the inland mill sites. By 1888 there were two (2) edge tool factories and factories for producing ink and blueing, cassimeres and satin, etc., cheese, warp, dies and power presses, cotton tickings, shirtings and denims. Eventually, other factories for producing machinery, such as pumps were built.

The Stream and Its Valley

The Quaboag River Basin is located in Central Massachusetts in Worcester, and Hampden Counties. The Quaboag River runs from Quaboag Pond in East Brookfield northwesterly to the south end of Wickaboag Pond in West Brookfield, thence southwesterly to Warren and westerly to Palmer and the Hampden County line. The river then flows south and west marking the border of Palmer until it turns north at the west end of Depot Village, where it joins the Ware and Swift Rivers in the community of Three Rivers to form the Chicopee River. The total length of the river from Quaboag Pond is about twenty-six (26) miles and its total drainage area is two hundred ten (210) square miles. The area of this Report is in Warren and lies in the southwesterly part of Worcester County and extends upstream from near the Palmer Town line on the north side of the river about six (6) miles to the West Brookfield Town line at Lamberton Brook.

The upper Quaboag River Basin above West Warren has a roughly oval shaped outline with West Warren at the southwesterly end of the oval. This watershed extends about eighteen (18) miles northeasterly from West Warren, about seventeen (17) miles to the east and up to eleven (11) north and three and a half ($3\frac{1}{2}$) miles south. The Quaboag River runs through the southerly quarter and westerly two thirds (2/3) of this watershed. The major tributaries come in from the north and northeast and include Lamberton Brook, Wickaboag Pond and its tributaries, Coys Brook, Trout Brook, Dunn Brook and Quaboag Pond and its tributary brooks. The major tributaries joining the Quaboag River in the area of this study are: School Street Brook, Crough Road Brook, O'Neil Brook, Cheney Brook, Comins Pond Brook, Sullivan Brook and Nautlaug Brook. These brooks are included in the areas listed in Table 1, Page 5.

The general topography of the basin above Warren consists of low rolling hills with some upland plains and broad flat flood plains with several broad shallow lakes. Maximum elevations are about 1,000 to 1,200 feet above mean sea level (msl). The flood plain of the Quaboag River above Warren is about elevation 590 to 600 feet msl. Wickaboag Pond and Quaboag Pond are slightly less than 600 feet in elevation msl. and Lake Lashaway is only 15 feet higher. The broad marshy flood plains and ponds in West Brookfield, Brookfield and East Brookfield provide significant natural storage that modifies storm runoff by delaying and reducing the peak runoff and prolonging the duration of high flows.

The reach of the Quaboag River from West Brookfield Road to West Warren and extending downstream to the U. S. Geological Survey Gaging Station is characterized by a narrow valley floor with only localized areas of moderate width - usually at the mouth of tributaries. The Quaboag River from West Brookfield Road to the U.S. Geological Survey Gage falls about 210 feet in $6\frac{1}{2}$ miles or about 32 feet per mile.

Tributaries in Warren - Most of the tributaries in Warren run generally north or south to the Quaboag River. The lengths are generally short, $1\frac{1}{4}$ to $2\frac{1}{2}$ miles long. They have steep gradients falling 140 to 200 feet per mile, with small drainage basins of under $2\frac{1}{2}$ square miles.

Nautlaug Brook, $3\frac{1}{2}$ miles long, and Lamberton Brook, $4\frac{1}{2}$ miles long, are transitional between the area of short steep brooks extending from Warren downstream to the West Brimfield gauge and the area of longer, flatter brooks extending from Wickaboag Pond to the east. The differences between these two areas is expressed in several ways.

1. The Quaboag River falls about 205 feet in less than $6\frac{1}{2}$ miles from old West Brookfield Road to the West Brimfield gage. This is a slope of about 32 feet per mile. From the outlet of Wickaboag Pond, two (2) miles above old West Brookfield Road, to Lake Lashaway the Quaboag River falls 22 feet in $5\frac{1}{2}$ miles or about 4 feet per mile.

2. The Quaboag River Valley in Warren has a narrow floor, often less than 300 feet wide including the river bed and seldom more than 1,000 feet wide. Above West Brookfield, the valley floor seldom measures less than 2,000 feet across the marshy flood plain.

3. The brooks in Warren run directly north or northwest and south or southeast to the Quaboag River, whereas the brooks eastward from Wickaboag Pond have much more complex, often meandering drainage patterns.

4. The tributaries in Warren have few ponds and narrow abrupt valley floors whereas the brooks east from Wickaboag Pond often have ponds and broad marshy flood plains in the valley floor.

TABLE 1

DRAINAGE AREAS

Location	Area Sq. Mi.	River Mile
Quaboag River at West Brimfield Gauge	150.6	9.00
Quaboag River at County Line	147.6	12.10
School Street Brook at mouth	1.2	12.50
Crough Road Brook at mouth (South of River)	1.4	12.80
O'Neil Brook at mouth	2.0	13.57
Cheney Brook at mouth	1.6	14.31
Comins Pond Brook at mouth (South of River)	2.3	15.00
Sullivan Brook at mouth	1.4	16.28
Nautlaug Brook at mouth (South of River)	4.0	16.49
Quaboag River at West Brookfield Town Line	128.5	17.05
Lamberton Brook	1.4	17.05

Tributaries East of Warren - The tributaries easterly from Wickaboag Pond are generally longer, (5 to 20 miles long), have larger drainage areas, (17 to 23 square miles), and flatter gradients, (15 to 50 feet of fall per mile). The terrain is not as precipitous and the many ponds and brookside marshes provide substantial channel storage that reduces, delays and prolongs peak runoff from the area.

The Quaboag River basin has a modified continental type of climate. It is generally warm to hot in the summer and moderately cold in the winter. The basin lies in the path of the "prevailing westerlies" and cyclonic disturbances that cross the country from the west or southwest producing frequent weather changes. The watershed is also exposed to occasional coastal storms that travel up the Atlantic Seaboard, some of which are of tropical origin and hurricane intensity. Tropical hurricanes constitute an infrequent but very important potential for flood-producing precipitation, particularly from August to October.

The average annual temperatures in the basin vary from 50°F in the mountainous regions to 55°F in the valleys. Recorded temperature extremes at representative stations within or adjacent to the Quaboag River basin have varied from a maximum of 100°F to a minimum of minus 20°F. Freezing temperatures have been experienced from the latter part of September until the early part of May.

The mean annual precipitation over the Quaboag River watershed is about 43-inches, ranging from less than 40-inches in the lower valley area to about 47-inches in the headwaters. The mean annual snowfall recorded at Westover Air Force Base at Chicopee Falls, Massachusetts, for 15 years of record, is 50-inches and at Hubbardston about 55-inches per year. The average maximum water content of the snowfall over the basin is about 5-inches. Melting snow alone seldom produces damaging high water on the Quaboag River or its tributaries, but snowmelt is often augmented by runoff from spring rainfall and results in substantially higher flood stages.

Agriculture in Warren is a minor industry and not as important in the economy of the Town as in areas to the east. Most of the land in Warren is too steep and the soil too stony and poor for productive farming. Most of the steep hills are covered by woodland.

Developments in the Flood Plain

The flood plain of the Quaboag River in Warren and West Warren is narrow, seldom exceeding 400 feet in width. There are substantial industrial, commercial, residential and community service developments in the flood prone areas. Much of the industrial basis of Warren's prosperity is located in or adjacent to the flood plain in West Warren and Warren. The commercial and civic center of Warren is adjacent to the Quaboag River at the mouth of Comins Pond Brook.

The principal communication routes for local traffic parallel the Quaboag River in or near the flood plain. The railroad follows the river closely to take advantage of the river grade. There are five (5) railroad bridges across the Quaboag River in the study area and in other critical locations. The railroad is adjacent to dams and other facilities.

The principal local highway, Route 67, crosses the river only once in Warren, but in many critical areas it is adjacent to the river and subject to flooding. The highway network serving adjacent upland areas branches from Route 67 and five (5) roads cross the river. Four (4) bridges are on roads connecting adjacent Towns and major countryside areas and the other bridge serves a local area and an old mill site. Throughout the length of Route 67, except in a few areas of new hillside locations, there are residential and commercial developments. Many of these developments are subject to flooding at times of high river stages.

Some of the facilities which may be subject to flooding include the businesses and residences near Gilbert Road, the William Wright Mill and adjacent neighborhood in West Warren, the area adjacent to the dam at Factory Road and along Route 67 to Town Farm Road, the "Fanny Jane" mill and adjacent houses, the Town Hall and commercial and industrial developments in Warren, some of the facilities between Old West Brookfield Road and the river and a few other scattered developments above Old West Brookfield Road.

The population of Warren has not changed dramatically since 1930, as indicated in Table 2 on Page 7.

TABLE 2

WARREN POPULATION TREND

Year	Population	% Change
1970	3587	+6.0
1960	3383	-0.7
1950	3406	-3.2
1940	3531	-6.2
1930	3765	--
1839	1196	--

FLOOD SITUATION

Sources of Data and Records

The U. S. Geological Survey has only one river gaging station on this watershed. This gage is about 3.2 miles downstream from the lower end of the study area and about 110 feet lower in elevation. The gage is located at latitude 42°-10'-31", longitude 72°-15'-46", on the right bank 15 feet upstream from the site of a former highway bridge at West Brimfield, Hampden County, 0.4 miles above Blodget Mill Brook and about 0.3 miles above Massachusetts Turnpike bridge. The records at this site have been compiled from twice daily gage height readings from 1909 to 1912 and a water stage recorder since 1912. Datum for the recorder is 377.36 feet above mean seal level datum of 1929. The drainage area at this site is 151 square miles with an average discharge from 1912 to 1973 of 240 cubic feet per second (cfs).

To supplement the records at the gaging station, documents and publications of the United States Geological Survey, U. S. Army Corps of Engineers, U. S. Department of Agriculture, Soil Conservation Service, U. S. Department of Commerce Weather Bureau and Worcester County Engineer have been researched for information concerning past floods. Published reports concerning floods since 1936 have been increasingly complete and informative.

Maps prepared for this Report were based on U. S. Geological Survey Topographic Quadrangle Sheet "Warren" 1969, 7½ minute series at 1" : 2000' horizontal scale and 10 feet contour interval. Structural data on bridges and dams were obtained by field surveys performed for the New England Division, Corps of Engineers and by research of records of the Massachusetts Department of Public Works and the Worcester County Engineer's office.

Crest stages and discharges for known floods at the West Brimfield gaging station are listed in Table 3.

TABLE 3

FLOOD CREST STAGES AND DISCHARGES

Quaboag River at West Brimfield Gage

Flood	Stage ft.	Peak Discharge cfs	cfs per sq. mi.	Storm Rainfall Inches
August 19,1955	14.79	12,800	84.8	16"
September 21,1938	11.80	8,470	56.1	12"
March 18,1936	* 7.60	3,620	24.0	--
March 17,1920	* 5.80	1,980	13.1	--
Standard Project	*16.80	14,000	93.0	--
Intermediate Regional	*10.10	6,500	43.1	--

* Estimated from rating curve

Flood Season and Flood Characteristics

Floods have occurred in the study reach of the Quaboag River during all seasons of the year with the majority occurring in spring. However, the two (2) largest floods in sixty (60) years of record occurred in August and September, with the former being the flood of record. Eight (8) of sixty (60) annual maximum floods occurred between December 10th and February 8th. Peak flood stages can be expected in Warren less than six (6) hours following the start of intense rainfall on the Quaboag River basin.

Melting snow alone seldom produces damaging high water on the Quaboag River or its tributaries, but snowmelt is often augmented by runoff from spring rainfall and results in substantially higher flood stages.

The Quaboag River watershed is also susceptible to cyclonic storms of continental origin, hurricanes of tropical origin, and thunderstorms. Hurricane type storms generally occur in late summer and fall and have caused the two most devastating floods in the basin.

Factors Affecting Flooding and Its Impact

Obstructions to floodflows - Natural obstructions to floodflows include trees, brush and other vegetation growing along the streambanks in floodway areas. Man-made encroachments on or over the streams such as dams, bridges and culverts can also create more extensive flooding than would otherwise occur. Representative obstructions to floodflows are shown in Figures 1 through 4.

Figure 1 - Gilbert Road Bridge showing low clearance and channel condition. Mile 12.3.

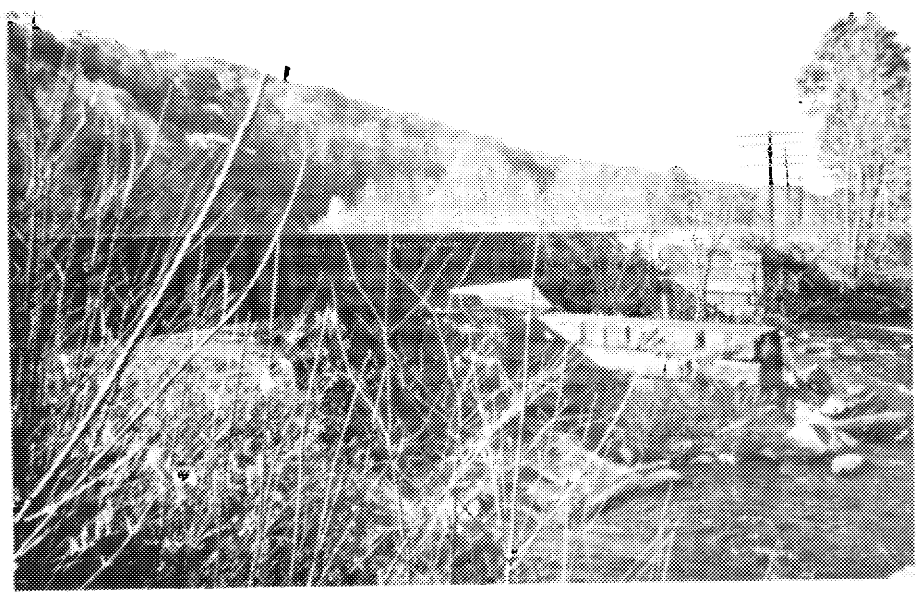


Figure 2 - Railroad Bridge above William Wright Mill and dams showing debris. Mile 13.4.

Figure 3 - West Warren, looking west from Town yard showing channel conditions and remains of dam. Mile 12.6.

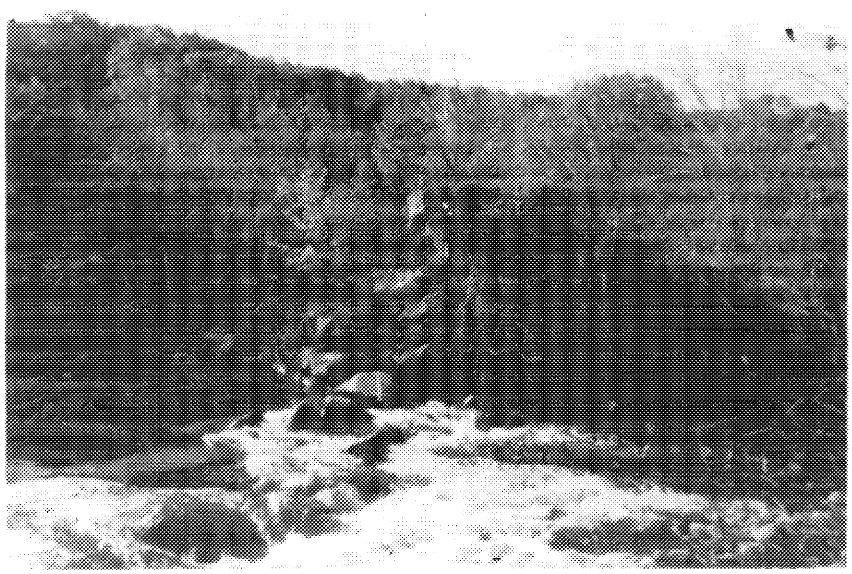


Figure 4 - West Warren, showing remains of dam above William Wright Mill. (Dam #2). Mile 13.3.

During floods, trees, brush and other vegetation growing in floodways impede floodflows, thus creating backwater and increased flood heights. Trees and other debris may be washed away and carried downstream to collect on bridges and other obstructions to flow. As floodflow increases, masses of debris break loose and a wall of water and debris surges downstream against a bridge until the load exceeds its structural capacity and the bridge is destroyed. The limited capacity of obstructive bridges or culverts, debris at the culvert mouth or a combination of these factors retard floodflows and result in flooding upstream, erosion around the culvert entrance and bridge approach embankments and possible damage to the overlying roadbed.

In general, obstructions restrict floodflows and result in overbank flows and unpredictable areas of flooding, destruction of, or damage to bridges and culverts, and an increased velocity of flow immediately downstream. It is impossible to predict the degree or location of the accumulation of debris; therefore, for the purposes of this report, it was necessary to assume that there would be no accumulation of debris to clog any of the bridge or culvert openings in the development of the flood profiles. The river is spanned twelve (12) times by bridges. In addition, there is one dam in use and the remains of two (2) dams still affect peak river flows to some extent. Two (2) of the bridges are shown in Figures 5 and 6. Pertinent information on all bridges can be found in Table 4. The dams are listed in Table 5 and the remains of William Wright Dam #2 is shown in Figure 4.

TABLE 4

ELEVATION DATA

Bridges on Quaboag River
Warren, Massachusetts

Identification	River Mile	Under-Clearance Elevation Ft., MSL	WATER SURFACE ELEVATIONS		
			Intermediate Regional Flood Ft., MSL	Standard Project Flood Ft., MSL	August 1955 Flood Ft., MSL
Penn-Central R. R. below Gilbert Rd.	12.10	494.5	491.8	497.3	496.8
Gilbert Rd.	12.30	497.0	499.7	501.6	501.3
Penn-Central R. R. above Gilbert Rd.	12.62	519.1	515.1	520.0	519.2
Oil Pipeline Bridge	12.88	527.2	520.0	523.6	532.2
Warren-Brimfield Rd.	12.90	548.0	520.8	524.8	532.5
Penn-Central R. R.above Wlm. Wright Dam #2	13.40	556.7	555.5	563.2	561.9
Factory Rd.	13.50	565.5	564.6	567.2	567.4
Penn-Central R. R. below Bridge St.	14.40	583.2	579.2	582.3	581.5
Bridge St.	14.70	585.6	582.6	586.2	585.1
Penn-Central R. R. below Main St.	14.75	589.8	585.9	592.2	589.7
Main St. (State Route 67)	15.05	595.8	592.0	595.7	595.0
Old West Brookfield Rd.	15.40	601.1	600.5	606.5	600.0**

** Estimated From Records At Other Points

TABLE 5

ELEVATION DATA

Dams on Quaboag River
Warren, Massachusetts

Identification	River Mile	Crest / Breach Ft., MSL	WATER SURFACE ELEVATIONS Intermediate Regional Flood Ft., MSL	Standard Project Flood Ft., MSL	August 1955 Flood Ft., MSL
William Wright Dam #1	13.00	532.6	538.3	540.3	538.8
William Wright Dam #2 (Ruins)	13.30	551.2 / 533.0	551.4	556.7	556.0
Willard Mfg. Co. (Ohio Carpet Co.) Dam #4 (Ruins)	13.55	564.5 / 555.0	566.0	568.0	567.6

Flood Damage Reduction Measures - In 1963 the U. S. Army Corps of Engineers completed a local flood protection project in West Warren to provide protection for the highly industrialized section of West Warren in the vicinity of the William Wright Mill and the Warren-Brimfield Road. This project consists of an earth and rockfill dike, concrete floodwalls, channel improvements, reconstruction of an existing bridge, and the removal of two (2) utility bridges. The project provides protection for a flood discharge of 11,000 cfs, which is more than the estimated discharge of the August, 1955 flood at this location and nearly equal to that of the Standard Project Flood. This project is illustrated in Figures 5 and 6.

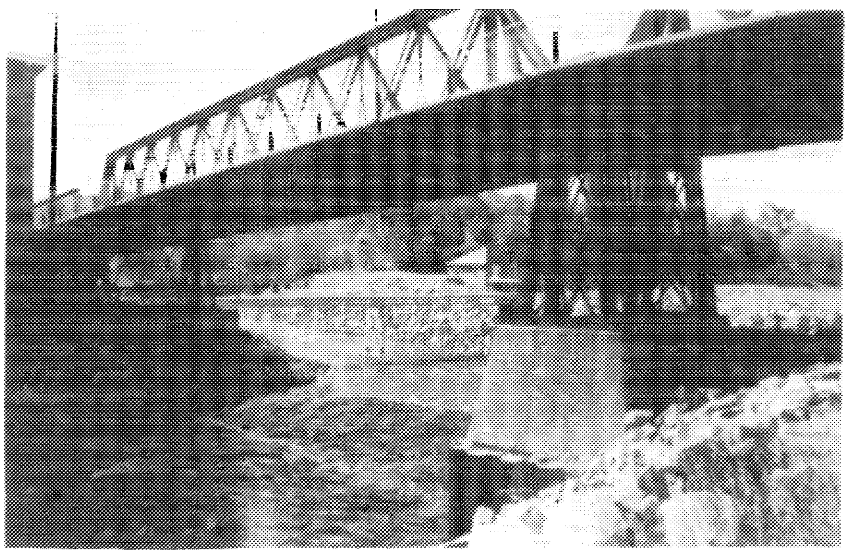


Figure 5 - West Warren local protection, showing Warren-Brimfield Road Bridge and downstream channel improvements. Mile 12. 9.

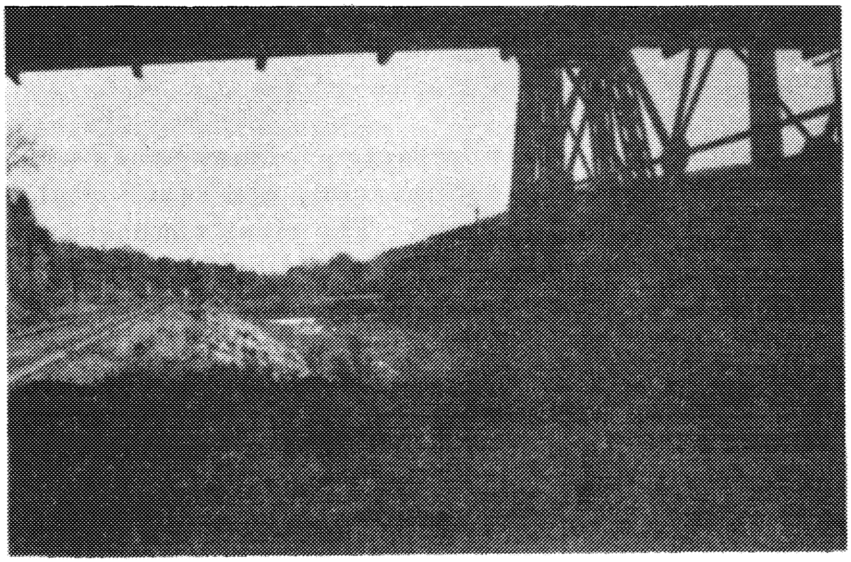


Figure 6 - West Warren local protection, showing upstream channel and dam improvements. Mile 12.9.

In 1961 the Soil Conservation Service of the U. S. Department of Agriculture prepared a Watershed Work Plan for the Upper Quaboag River Watershed. One of the objectives of this plan is the reduction of flood peak discharges. This project includes ten (10) structural measures as well as land management practices to be applied wherever possible. The structural measures include nine (9) reservoirs, all of which will have flood detention and flood peak reduction capabilities. Five (5) of the reservoirs and a flood wall have been built and are in service providing flood protection. Four (4) additional reservoir sites are to be developed or improved.

The Town of Warren has no building code, subdivision or zoning ordinances or other regulatory measures that specifically control flood plain development. The Town of West Brookfield is the only town in the area with such ordinances. However, the Massachusetts Water Resources Commission, created under the provisions of Chapter 620 of the Acts of 1956, has, among its other duties, the responsibility for the development of flood prevention and coordination of the activities of the Federal, State and other agencies in this field.

The Massachusetts Legislature has increased the authority of the Water Resources Commission to regulate the use of flood plains and to establish floodways on certain streams (Chapters 548 and 544 of the Acts of 1961).

Other Factors and Their Impacts - Many areas which have been developed for industrial, commercial, and residential purposes are located in the flood plains. The river channel in many places is restricted by buildings, dams, and bridges. Many of these structures collect debris which augments high flood levels. The depth of overbank flooding, the concentration of flow, and the steep hydraulic characteristics of the flooded area in some places produce damaging flood velocities.

Flood Warning and Forecasting - The U. S. Department of Commerce, National Weather Service, is responsible for forecasting high water on the nation's rivers and for issuing flood warnings for the protection of life and property. The National Weather Service River Forecast Center at Hartford, Connecticut, is responsible for issuing flood warnings for the Chicopee River basin. Flood warnings and anticipated weather conditions are issued by the National Weather Service to State Police, Massachusetts Civil Defense and news and press media wire service for further dissemination to residents of the area. Flood warning and alerts are relayed by the Massachusetts and local civil defense agencies working in conjunction with the police and other Warren Town agencies.

In addition to the flood warning and forecasting service, the Corps of Engineers operates an Automatic Hydrologic Radio Reporting Network. This network, under computer programmed control, will immediately provide read-out information which is essential for the regulation of flood control dams. One station in the Chicopee River basin reports river stages. The real time print-out on the computer of high streamflows will assure early warning to Division personnel for immediate operation of Barre Falls flood control dam and other protection works.

Flood Fighting and Emergency Evacuation Plans - State and Local civil defense staffs have flood fighting and emergency evacuation plans and contacts in the area. There are provisions for alerting area residents and coordinating operations of various public emergency service agencies and activities in time of emergency. State and local civil defense agencies maintain communications with police and fire department headquarters where watch is maintained 24-hours a day and emergency reports are received. Information on flood preparation or evacuation is disseminated through commercial broadcast stations, television, and news media and if necessary, via telephone, mobile public address systems or personal contact sent to the threatened areas.

Material Storage on the Flood Plain - Due to the intense industrial development along the Quaboag River, there are large quantities of floatable materials stored on flood plain lands. The Penn Central Railroad has spur tracks to many of the plants along the river. Much material is handled and transshipped on these tracks, some of which are subject to inundation by floods. Much of the material handled is floatable such as lumber, crates and large-volume lightweight containers. There are, also, many storage tanks which may be unrestrained and buoyant. During time of floods, these floatable materials may be carried away by flood-flows causing serious damage to structures downstream and could clog bridge openings creating more hazardous flood problems.

PAST FLOODS

Summary of Historical Floods

Major historical floods in the Quaboag River basin include those of May,1854 and October, 1869. On the basis of meagre and unreliable records it would appear that these floods never approached the magnitude of the major floods which occurred in and after 1936. However, the earlier floods may have been of greater volume than has been assumed and the paucity of records may reflect the lesser importance those floods had to the inhabitants of the basin than more recent floods.

In the Quaboag River basin four (4) floods of major proportions have been experienced since 1936. They occurred in March, 1936 (2 floods), September, 1938 and August, 1955.

Flood Records

The U. S. Geological Survey has one gaging station on the Quaboag River at West Brimfield located about 0. 3 miles above the Massachusetts Turnpike bridge. Records at this gage from 1912 to 1973 were used extensively in developing the hydrologic analysis of the Quaboag River. Studies of the Soil Conservation Service were also used in evaluating floods and future floods. High water marks of past floods were obtained from published reports, newspaper files, county engineers' records and interviews with residents.

Flood Descriptions

The following are descriptions of known large floods that have occurred in the Quaboag River basin. Flood scenes are shown in Figures 7, 8 and 9.

Floods of March 1936. The first of the two March 1936 floods was caused by a combination of rainfall and snowmelt. The second flood, which was more destructive, involved only minor amounts of snowmelt but had considerably more rainfall. Also, it followed the first flood so closely that the river channels were still nearly bank full and the ground practically saturated. At West Brimfield on the Quaboag River (DA = 151 square miles) the peak discharge of the second rise was about 3,600 cfs on March 19, 1936. (See Figures 7 through 10).

September 1938 Flood. The September, 1938 storm produced the greatest flow of record along the Ware, Swift and Chicopee Rivers. Antecedent rainfall and runoff had filled many natural storage areas in the basin by the time of the most intense rainfall. As a result, the time sequence of this hurricane storm was conducive to high peak discharges. The maximum discharge on the Quaboag River at West Brimfield was 8,470 cfs or 56 cfs per square mile. During the period from September 17-21 nearly 13-inches of rain fell at West Brookfield, Massachusetts, 7-inches of which occurred during the night of September 20-21. The average rainfall for the watershed was about 11.5-inches and ranged from 10-inches to over 13-inches.

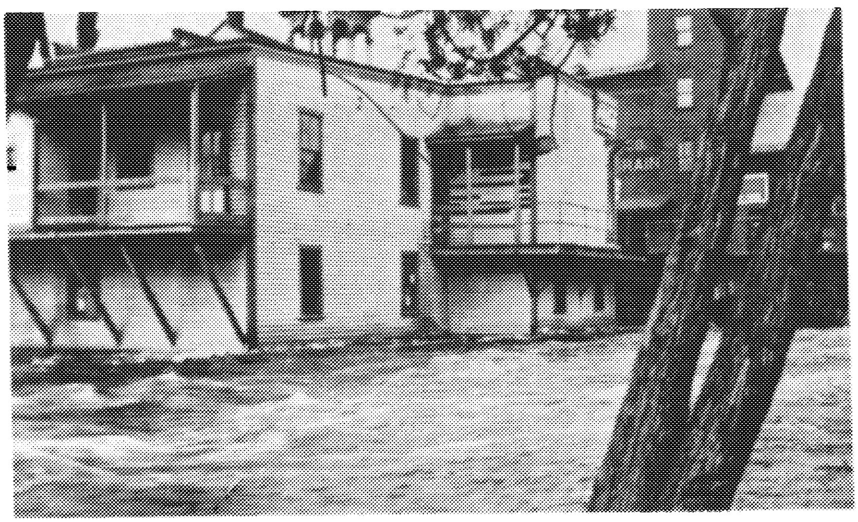


Figure 7 - Flood of March 1936. Puskey's Store at Main Street Bridge, Warren. Mile 15.0.

Figure 8 - Flood of March 1936, near Puskey's Store, Warren. Mile 14.9.

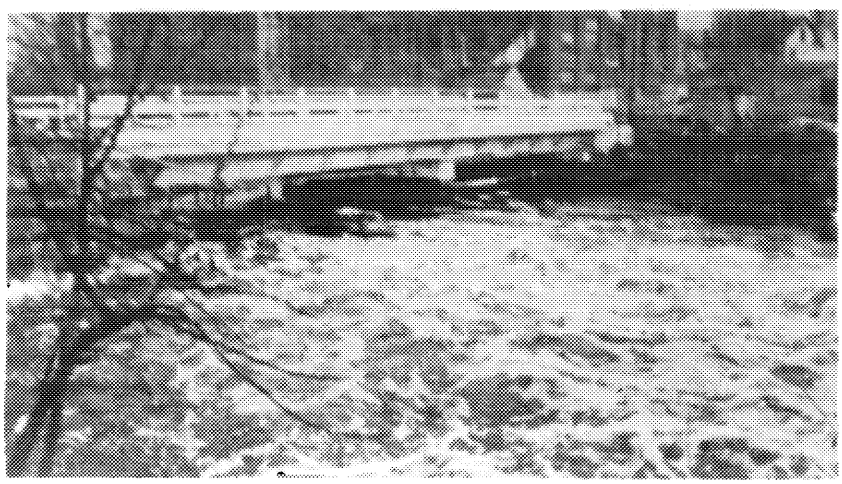


Figure 9 - Flood of March 1936. Fanny Jane Mill and bridge, Warren. Mile 14.7.

<u>August 1955 Flood.</u> The August 1955 flood produced by far the greatest flows of record along the Quaboag River. At West Brimfield the peak discharge was 12,800 cfs (85 csm) or about 50% greater than the previously recorded maximum discharge of 8,500 cfs (56 csm) in September, 1938. Flooding on the Quaboag River was caused by heavy precipitation accompanying hurricane "Diane" (August 17-20), which deposited from 15 to 18-inches of rain over the basin. About 17.5-inches of rain fell at West Brookfield. Nearly 11-inches fell between midnight and noon on August 19th.

Direct damage amounted to over $2,300,000 in the upper Quaboag River watershed. Approximately eleven (11) industrial, commercial and public buildings and over 200 homes suffered severe damage. Traffic on the Penn-Central Railroad was suspended for several weeks. Many roads and bridges were damaged causing rerouting of traffic on major highways as well as on Town roads.

FUTURE FLOODS

Floods of the same or larger magnitudes as those that have occurred in the past could occur in the future. Larger floods have been experienced in the past on streams with similar geographical and physiographical characteristics as those found in the study area. Similar combinations of rainfall and runoff which caused these floods could occur in the study area. Therefore, to determine the flooding potential of the study area, it was necessary to consider storms and floods that have occurred in regions of like topography, watershed cover and physical characteristics. Discussion of the future floods in this report is limited to those that have been designated as the Intermediate Regional Flood and the Standard Project Flood. The Standard Project Flood represents a reasonable upper limit of expected flooding in the study area. The Intermediate Regional Flood may reasonably be expected to occur more frequently although it will not be as severe as the infrequent Standard Project Flood.

Intermediate Regional Flood

The Intermediate Regional Flood is defined as one that could occur once in 100 years on the average, although it could occur in any year. The limits of this flood are used by Federal and State agencies, and cities and towns, as minimum criteria in establishing flood plain zoning in communities. The peak flow of this flood was developed from statistical analyses of stream flow and precipitation records and runoff characteristics for the stream. In determining the Intermediate Regional Flood for the Quaboag River, statistical studies were made using the record of flood data from the U. S. Geological Survey gauging station at West Brimfield. Peak flow thus developed for the Intermediate Regional Flood is shown in Table 3, Page 9.

Standard Project Flood

The Standard Project Flood is defined as a major flood that can be expected to occur from a severe combination of meteorological and hydrological conditions that is considered reasonably characteristic of the geographical area in which the study area is located, excluding extremely rare combinations. The Corps of Engineers, in cooperation with the National Weather Service, has made comprehensive studies and investigations based on the past records of experienced storms and floods and has developed generalized procedures for estimating the flood potential of streams. Peak flows developed for the Standard Project Flood for West Brimfield are shown on Table 3, Page 9. The Standard Project Flood is used by the Corps of Engineers in the design of local protection works.

Frequency

A frequency curve of peak flows at the West Brimfield gage was constructed. This frequency curve was used to determine the probable discharge of future floods of various frequencies. This curve, together with estimates of discharge at other locations and hydrologic studies of the upper Quaboag River basin were used to estimate discharge-frequency data for other points along the river. Thus, this data reflects the analysis of much historical data and extensive studies of the area by specialists. However, these data indicate the approximate range of discharge over a long period of time and a flood larger than the rare Standard Project Flood could occur at any time.

Table 6, following, lists Quaboag River discharge used in this study for the Intermediate Regional Flood, Standard Project Flood and August 1955 Flood. Discharges are listed for locations at the West Brimfield Gage, county line just below the railroad bridge west of West Warren, above School Brook, above O'Neil Brook, at Main Street Bridge in Warren, and below Lamberton Brook at the West Brimfield Town line.

TABLE 6

DISCHARGE - FREQUENCIES

WARREN, MASSACHUSETTS

Location	River Mile (mi.)	Drainage Area (sq. mi.)	DISCHARGES IRF (cfs)	SPF (cfs)	Aug. 1955 (cfs)
West Brimfield Gage	9.00	150.6	6,500	14,000	12,800
County Line	12.10	147.6	5,905	12,545	11,483
Above School St. Brook	12.51	145.1	5,515	11,460	10,462
Above O'Neil Brook	13.58	140.8	4,785	9,645	8,842
Main St. (Rte. 67)Bridge	15.05	135.8	4,075	7,605	7,048
West Brookfield Town Line	17.05	128.5	3,710	6,000	5,603

Hazards of Large Floods

The extent of damage caused by any flood depends on the topography of the area flooded, depth and duration of flooding, velocity of flow, rate of rise, and developments in the flood plain. An Intermediate Regional Flood or Standard Project Flood on the Quaboag River would result in inundation of residential, commercial, and industrial sections in some parts of the study area. Deep floodwater flowing at high velocity and carrying floating debris would create conditions hazardous to persons and vehicles attempting to cross flooded areas. In general, floodwater 3 or more feet deep and flowing at a velocity of 3 or more feet per second could easily sweep an adult person off his feet, thus creating definite danger of injury or drowning. Rapidly rising and swiftly flowing floodwater may trap persons in homes that are ultimately destroyed or in vehicles that are ultimately submerged or floated. Water lines can be ruptured by deposits of debris and the force of floodwaters, thus creating the possibility of contaminated domestic water supplies. Damaged sanitary sewer lines and sewage treatment plants could result in the pollution of floodwaters creating health hazards. Isolation of areas by floodwater could create hazards in terms of medical, fire, or law enforcement emergencies.

Flooded Areas and Flood Damages - The areas in Warren that would be flooded by the Standard Project Flood are shown on Plate 2, which is also an index map to the succeeding plates. Areas that would be flooded by the Intermediate Regional and Standard Project Floods are shown in detail on these plates. The actual limits of these overflow areas may vary somewhat from those shown on the maps because the 10-foot contour interval and scale of the maps do not permit precise plotting of the flooded area boundaries. These plates show the parts of the community that would be covered by the Intermediate Regional and Standard Project Floods during floodflows. The areas that would be flooded include commercial, industrial, and residential sections and the associated streets, roads, and public and private utilities. Considerable damage to these facilities could occur during floods.

The flood of record along the Quaboag River occurred in August, 1955 and caused an estimated $2,300,000 in direct damages (1955 prices). Indirect damages, such as loss of business with consequent unemployment, and disruption of transportation and communications with resultant inconvenience to the public and industry, would amount to considerably more. Direct damages were to industrial buildings, highway and railroad bridges, road and railroad washouts, destruction of homes and stores, and destruction of farmland. A recurrence of this flood could cause greater damages in terms of current costs. A study of the following plates will show where future floods could extend and existing or future buildings in these areas could suffer considerable damages.

Obstructions - During floods, debris collecting on bridges and culverts could decrease their carrying capacity and cause greater water depths (backwater effect) upstream of these structures. Since the occurrence and amount of debris are indeterminate factors, only the physical characteristics of the structures were considered in preparing profiles of the Intermediate Regional and Standard Project Floods. Similarly, the maps of flooded areas show the backwater effect of obstructive bridges and culverts, but do not reflect increased water surface elevation that could be caused by debris collecting against the structures, or by deposition of silt in the stream channel under structures. As previously indicated, there are three (3) dams within the study area. These dams have neither flood control capacities nor will they seriously alter flow characteristics of flood waters. Most of the twelve (12) bridges crossing the stream in the study area are obstructive to the Intermediate Regional Flood. In some cases bridges may be high enough to avoid inundation by floodflows; but the approaches to these bridges may be at lower elevations and subject to flooding and rendered impassable. Table 4 lists the bridges and Table 5 lists the dams on the stream and shows their relationship to the Intermediate Regional and Standard Project Floods.

Velocities of Flow - Water velocities during floods depend largely on the size and shape of the cross-sections, conditions of the stream, and the bed slope, all of which vary on different streams and at different locations on the same stream. During an Intermediate Regional Flood, velocities in the main channel would be from 5 to 14 feet per second (fps). Water flowing at this rate is capable of causing severe erosion to stream banks and fill around bridge abutments and transporting large objects.

It is expected that velocities would be somewhat higher during a Standard Project Flood than during an Intermediate Regional Flood. Velocities would range from 5 to 16 feet per second. Water flowing 20 fps may dislodge boulders weighing up to 1500 pounds.

Rates of Rise and Duration of Flooding - Peak flood stages can be expected on the main stem about 6-hours following the start of intense rainfall on the Quaboag River basin. The Quaboag River can experience a rate of rise of approximately $1\frac{1}{2}$ feet per hour. The duration of flooding at various points along the river can be expected to vary from 1 to 8 days, depending upon the magnitude and type of the flood and degree of susceptibility of the site.

Photographs, Future Flood Heights - The levels that the Intermediate Regional and Standard Project Floods are expected to reach at various locations along the Quaboag River are indicated on the following photographs, Figures 10 through 15.

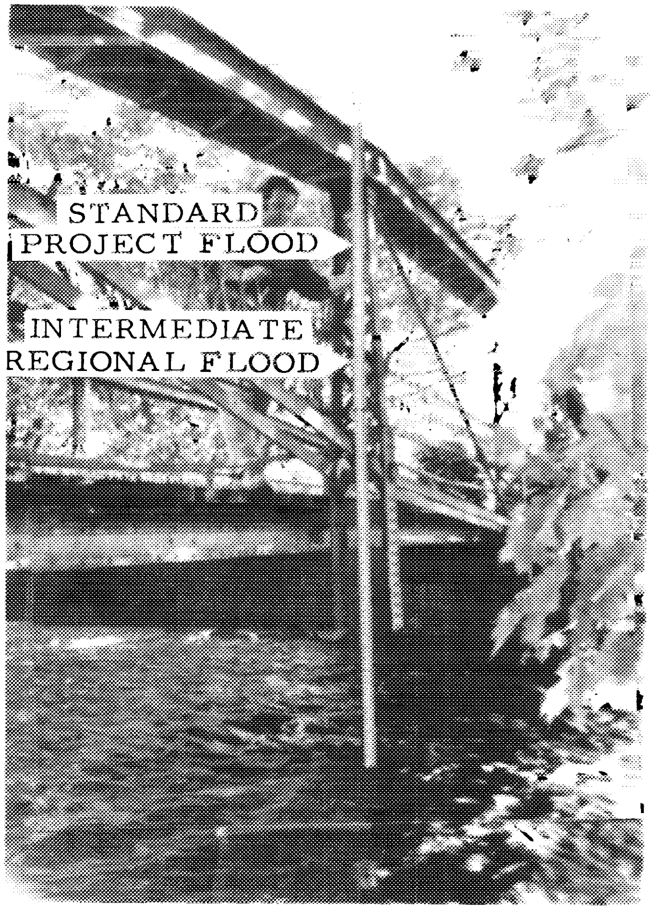


Figure 10 - Future flood heights at Gilbert Road. Mile 12.3.

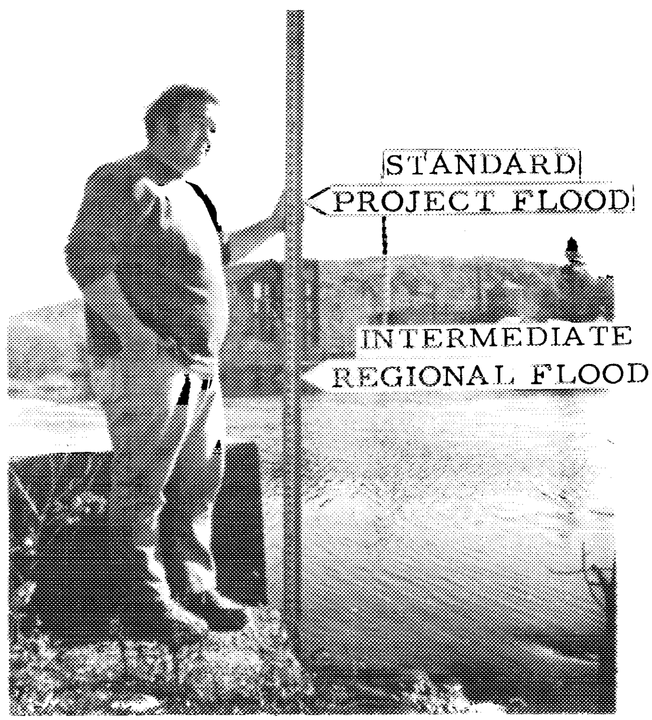


Figure 11 - Future flood heights at William E. Wright Dam. Mile 13.0.

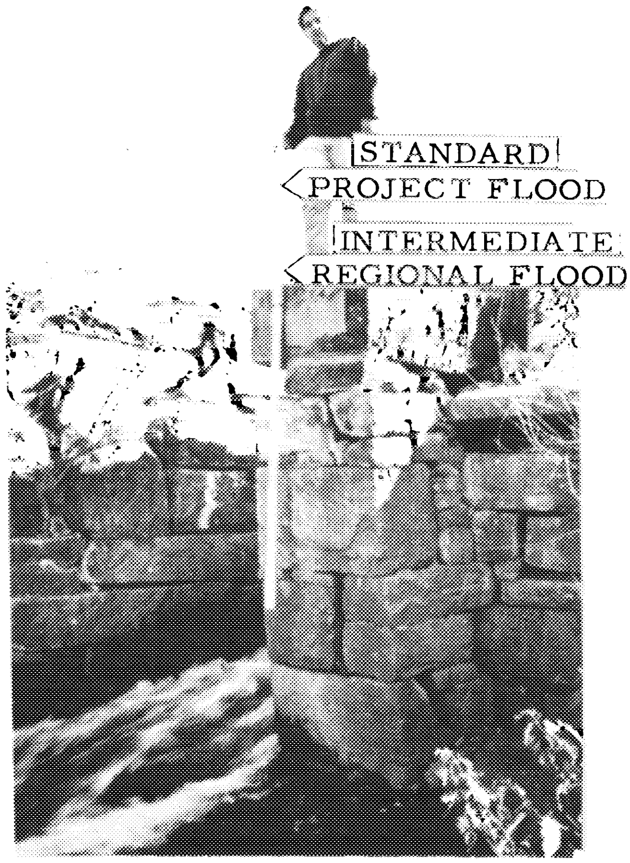


Figure 12 - Future flood heights below Willard
Manufacturing Company Dam #4. Mile 13.55.

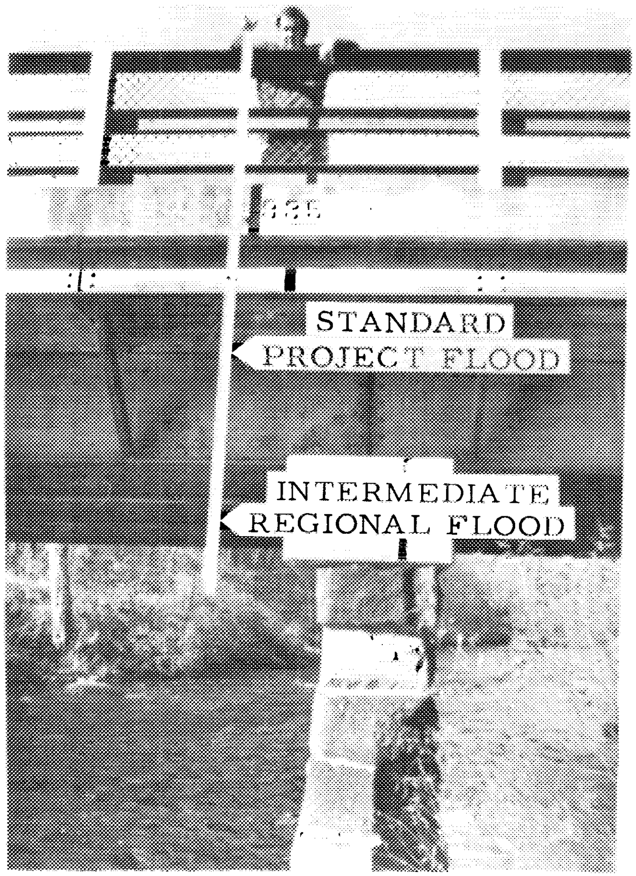


Figure 13 - Future flood heights at Fanny Jane Bridge, Bridge Street. Mile 14. 7.

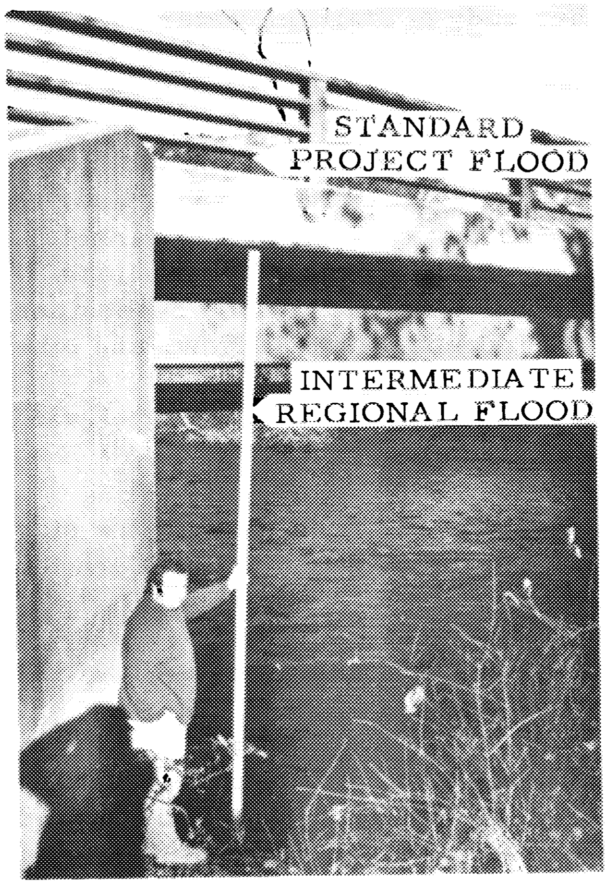


Figure 14 - Future flood heights at Old West Brookfield Road. Mile 15.3.

GLOSSARY

Backwater. The resulting high water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.

Flood. An overflow of water onto lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: The inundation of land is temporary; and the land is adjacent to and inundated by overflow from a river or stream or an ocean, lake, or other body of standing water.

Normally, a "flood" is considered as any temporary rise in streamflow or stage, but not the ponding of surface water that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, rise of ground water coincident with increased streamflow, and other problems.

Flood Crest. The maximum stage or elevation reached by the waters of a flood at a given location.

Flood Hydrograph. A graph showing the stage in feet against time at a given point and the rate of rise and duration above flood stage.

Flood Plain. The areas adjoining a river, stream, watercourse, ocean, lake, or other body of standing water, which has been or may be covered by floodwater.

Flood Profile. A graph showing the relationship of water surface elevation to location, the latter generally expressed as distance above mouth for a stream of water flowing in an open channel. It is generally drawn to show surface elevation for the crest of a specific flood, but may be prepared for conditions at a given time or stage.

Flood Stage. The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Hurricane. An intense cyclonic windstorm of tropical origin in which winds tend to spiral inward in a counterclockwise direction toward a core of low pressure with maximum surface wind velocities that equal or exceed 75 miles per hour (65 knots) for several minutes or longer at some points. Tropical storm is the term applied if maximum winds are less than 75 miles per hour.

Intermediate Regional Flood. A flood having an average frequency of occurrence in the order of once in 100 years although the flood may occur in any year. It is based on statistical analyses of streamflow records available for the watershed and analyses of rainfall and runoff characteristics in the "general region of the watershed."

Left Bank. The bank on the left side of a river, stream or watercourse looking downstream.

Right Bank. The bank on the right side of a river, stream or watercourse looking downstream.

Standard Project Flood. The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharges for these floods are generally about 40% to 60% of the Probable Maximum Floods for the same basins. Such floods, as used by the Corps of Engineers, are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

Underclearance Elevation. The elevation at the top of the opening of a culvert or other structure through which water may flow along a watercourse. This is referred to as "low steel" in some regions.

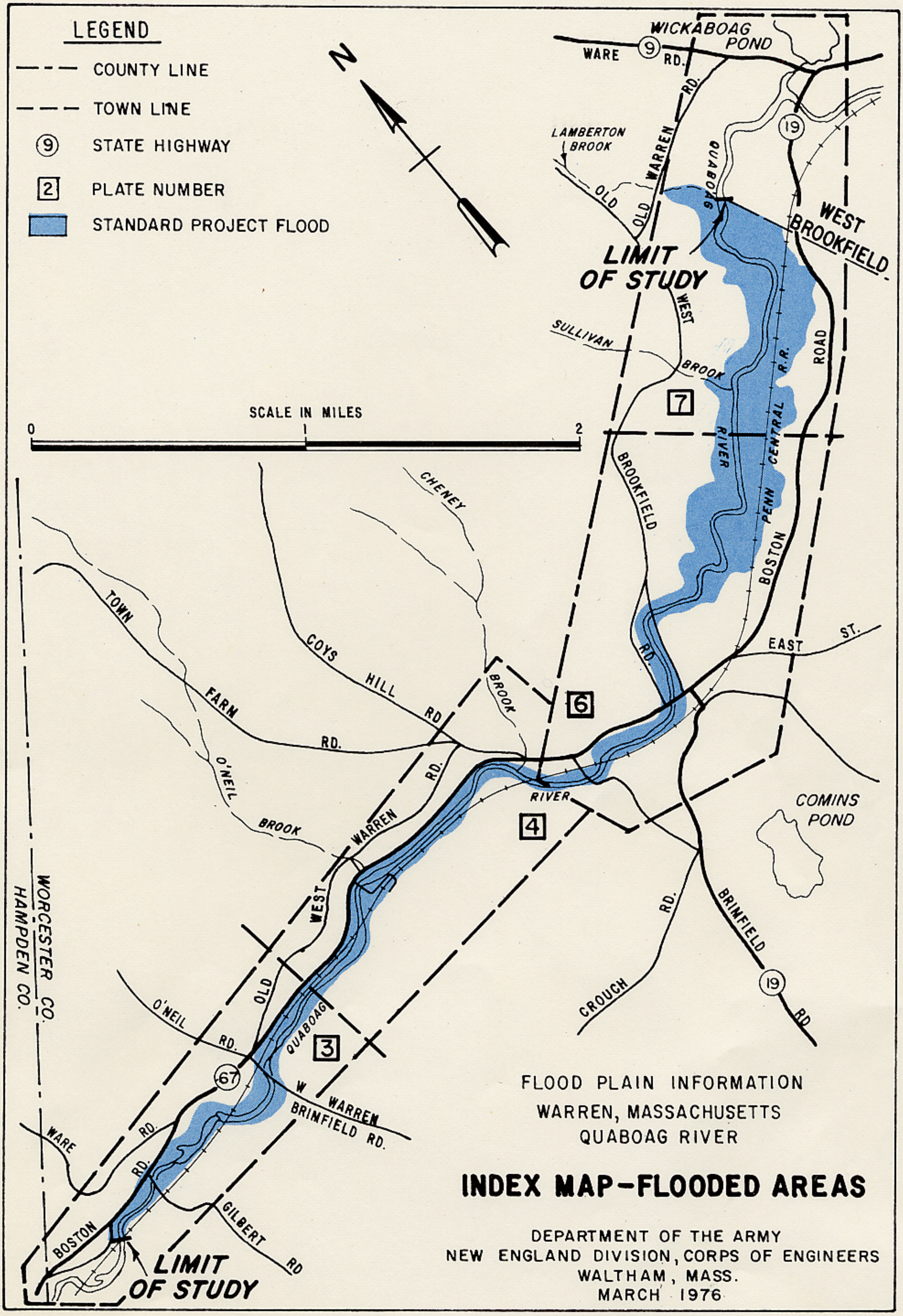
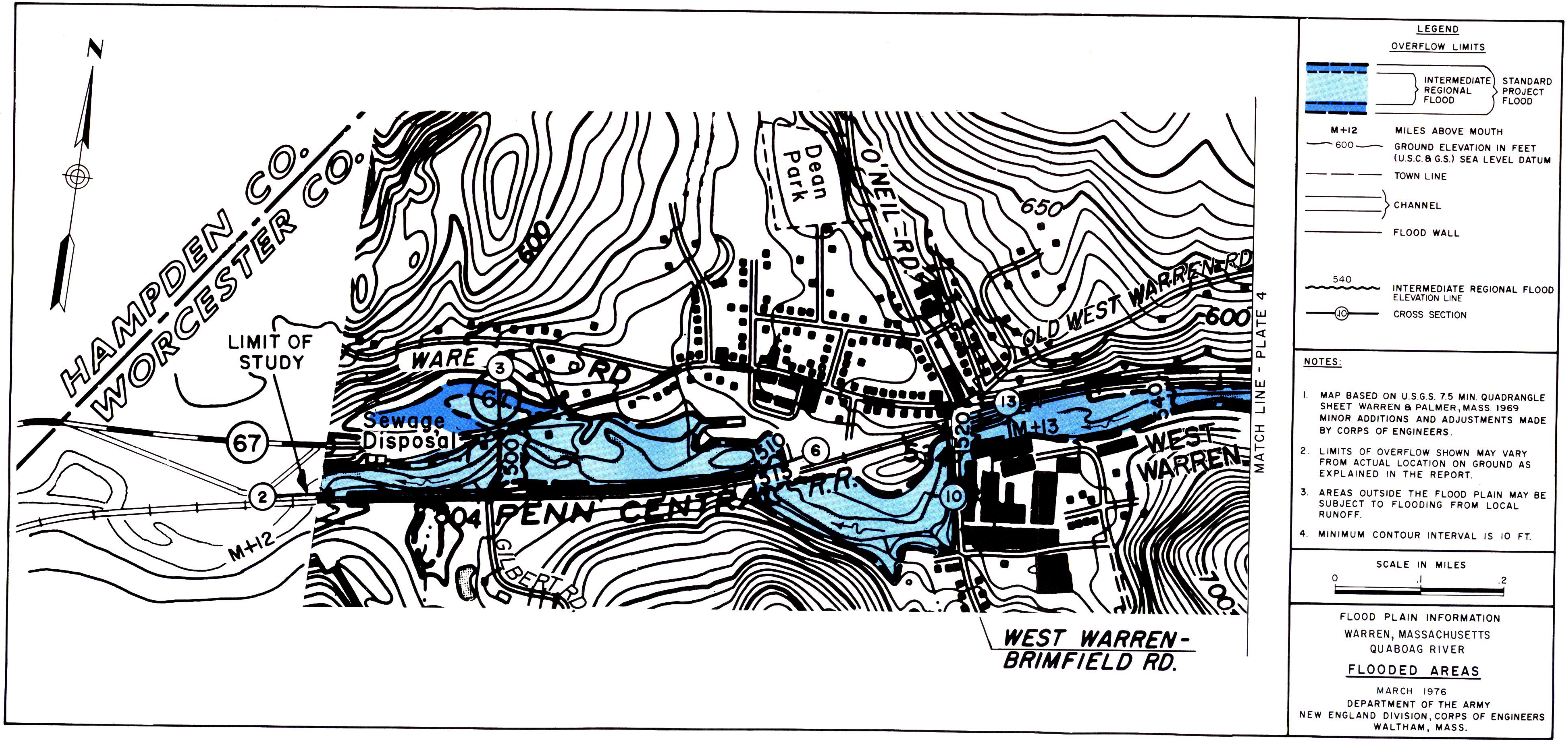

LEGEND
COUNTY LINE
TOWN LINE
9 STATE HIGHWAY
2 PLATE NUMBER
STANDARD PROJECT FLOOD
N
SCALE IN MILES
0
1
2
WICKABOAG POND
WARE 9 RD.
WARREN RD.
LAMBERTON BROOK
OLD OLD RD.
QUABOAG
19
WEST BROOKFIELD
LIMIT OF STUDY
WEST
SULLIVAN BROOK
7
RIVER
PENN CENTRAL R.R.
ROAD
BROOKFIELD RD.
BOSTON
CHENEY BROOK
TOWN FARM RD.
COYS HILL RD
EAST ST.
6
O'NEIL BROOK
WARREN RD.
RIVER
4
COMINS POND
WEST
OLD
RD.
BRIMFIELD
19
RD
CROUCH
WORCESTER CO.
HAMPDEN CO.
O'NEIL RD.
QUABOAG
3
67
W WARREN
BRIMFIELD RD.
WARE
RD.
RD.
GILBERT RD
BOSTON
LIMIT OF STUDY
FLOOD PLAIN INFORMATION
WARREN, MASSACHUSETTS
QUABOAG RIVER
INDEX MAP-FLOODED AREAS
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
MARCH 1976

PLATE 2


N
HAMPDEN CO.
WORCESTER CO.
LIMIT OF STUDY
67
2
M+12
WARE RD
3
6
Sewage Disposal
500
504
PENN CENTRAL R.R.
GILBERT RD
510
515
6
Dean Park
O'NEIL RD
650
600
OLD WEST WARREN RD
13
M+13
520
540
10
WEST WARREN
700
WEST WARREN-BRIMFIELD RD.
MATCH LINE - PLATE 4
LEGEND
OVERFLOW LIMITS
INTERMEDIATE REGIONAL FLOOD
STANDARD PROJECT FLOOD
M+12 MILES ABOVE MOUTH
600 GROUND ELEVATION IN FEET (U.S.C.& G.S.) SEA LEVEL DATUM
TOWN LINE
CHANNEL
FLOOD WALL
540 INTERMEDIATE REGIONAL FLOOD ELEVATION LINE
10 CROSS SECTION
NOTES:
1. MAP BASED ON U.S.G.S. 7.5 MIN. QUADRANGLE SHEET WARREN & PALMER, MASS. 1969 MINOR ADDITIONS AND ADJUSTMENTS MADE BY CORPS OF ENGINEERS.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOOD PLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. MINIMUM CONTOUR INTERVAL IS 10 FT.
SCALE IN MILES
0 .1 .2
FLOOD PLAIN INFORMATION
WARREN, MASSACHUSETTS
QUABOAG RIVER
FLOODED AREAS
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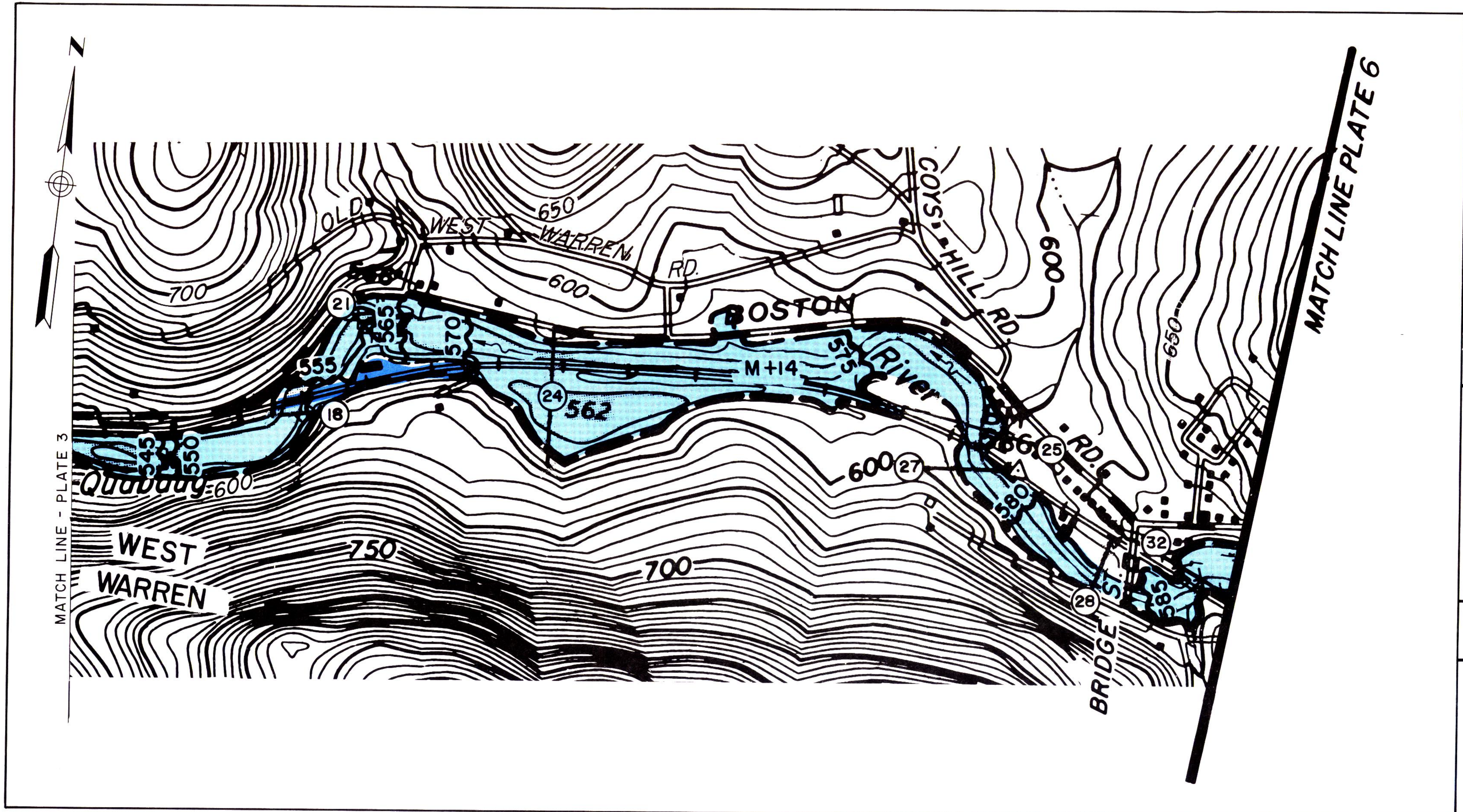
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 3



LEGEND

OVERFLOW LIMITS

INTERMEDIATE REGIONAL FLOOD
STANDARD PROJECT FLOOD

M+17 MILES ABOVE MOUTH

600 GROUND ELEVATION IN FEET (U.S.C.& G.S.) SEA LEVEL DATUM

TOWN LINE

CHANNEL

FLOOD WALL

580 INTERMEDIATE REGIONAL FLOOD ELEVATION LINE

24 CROSS SECTION

NOTES:

1. MAP BASED ON U.S.G.S. 7.5 MIN. QUADRANGLE SHEET WARREN, MASS. 1969 MINOR ADDITIONS AND ADJUSTMENTS MADE BY CORPS OF ENGINEERS.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOOD PLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. MINIMUM CONTOUR INTERVAL IS 10 FT.

SCALE IN MILES

0 .1 .2

FLOOD PLAIN INFORMATION

WARREN, MASSACHUSETTS

QUABOAG RIVER

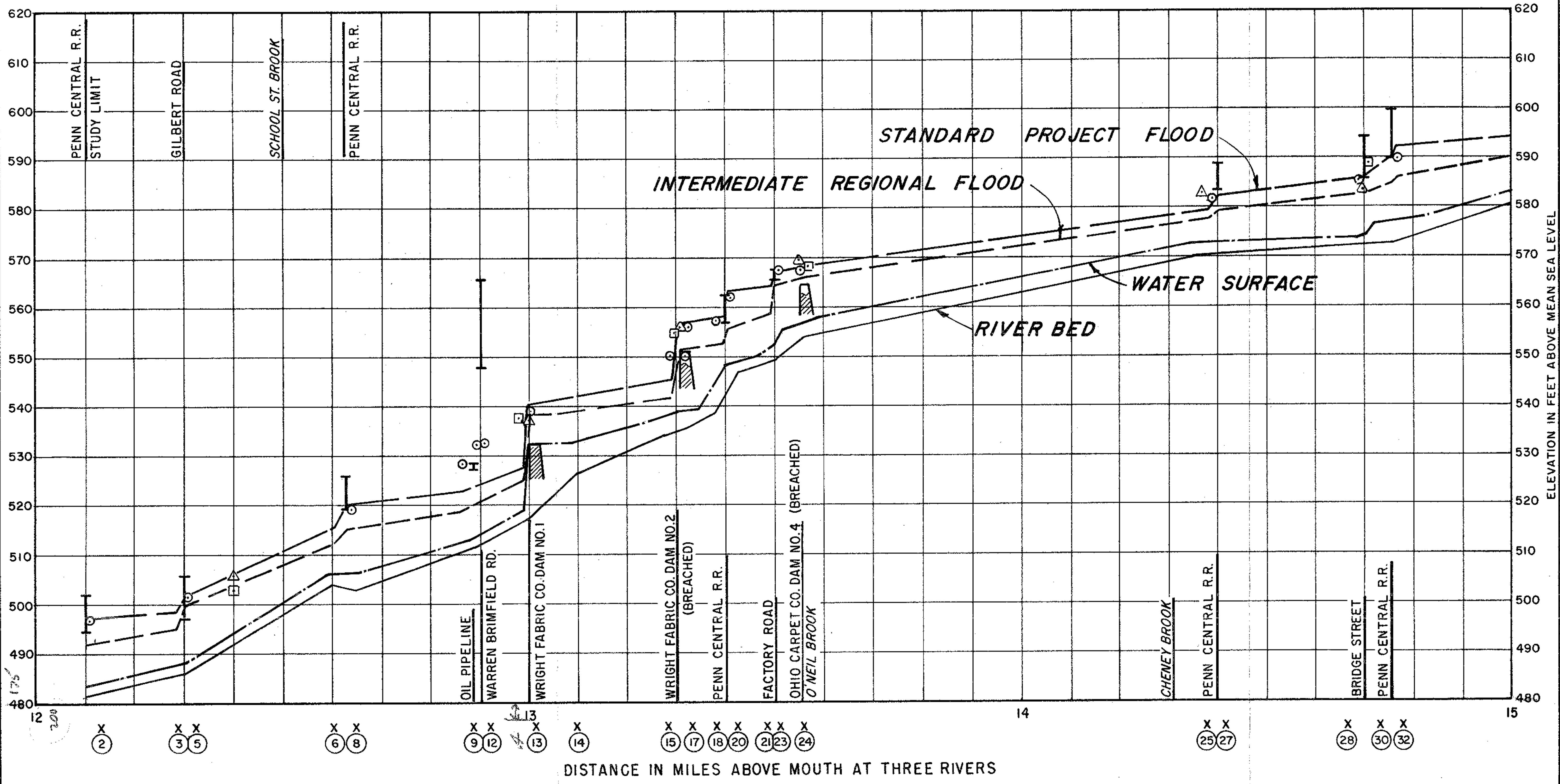
FLOODED AREAS

MARCH 1976

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASS.



LEGEND

HIGH WATER EXPERIENCED

- ○ AUGUST 1955
- △ SEPTEMBER 1938
- □ MARCH 1936
- I BRIDGE
- DAM
- CROSS SECTION

FLOOD PLAIN INFORMATION
WARREN, MASSACHUSETTS
QUABOAG RIVER

HIGH WATER PROFILES

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WALTHAM, MASS.

PLATE 5

LEGEND

OVERFLOW LIMITS

INTERMEDIATE REGIONAL FLOOD | STANDARD PROJECT FLOOD

M+17 MILES ABOVE MOUTH

650 GROUND ELEVATION IN FEET (U.S.C.& G.S.) SEA LEVEL DATUM

TOWN LINE

CHANNEL

FLOOD WALL

600 INTERMEDIATE REGIONAL FLOOD ELEVATION LINE

41 CROSS SECTION

NOTES:

1. MAP BASED ON U.S.G.S. 7.5 MIN. QUADRANGLE SHEET WARREN, MASS. 1969 MINOR ADDITIONS AND ADJUSTMENTS MADE BY CORPS OF ENGINEERS.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOOD PLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. MINIMUM CONTOUR INTERVAL IS 10 FT.

SCALE IN MILES

0 .1 .2

FLOOD PLAIN INFORMATION

WARREN, MASSACHUSETTS

QUABOAG RIVER

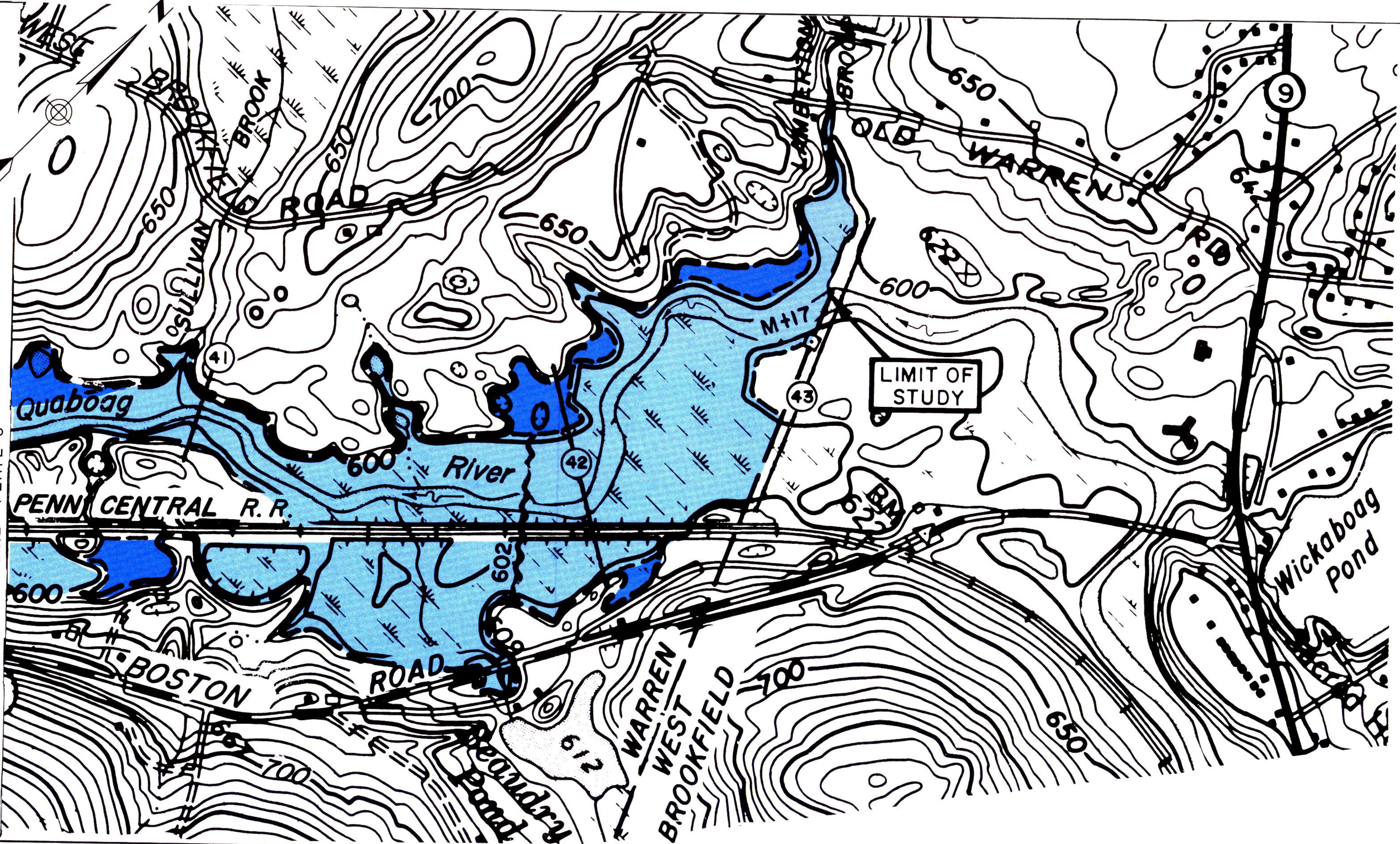
FLOODED AREAS

MARCH 1976

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASS.



LEGEND

OVERFLOW LIMITS

INTERMEDIATE REGIONAL FLOOD
STANDARD PROJECT FLOOD

M+17 MILES ABOVE MOUTH

600 GROUND ELEVATION IN FEET (U.S.C.& G.S.) SEA LEVEL DATUM

TOWN LINE

CHANNEL

FLOOD WALL

602 INTERMEDIATE REGIONAL FLOOD ELEVATION LINE

43 CROSS SECTION

NOTES:

1. MAP BASED ON U.S.G.S. 7.5 MIN. QUADRANGLE SHEET WARREN, MASS. 1969 MINOR ADDITIONS AND ADJUSTMENTS MADE BY CORPS OF ENGINEERS.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOOD PLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. MINIMUM CONTOUR INTERVAL IS 10 FT.

SCALE IN MILES

0 .1 .2

FLOOD PLAIN INFORMATION
WARREN, MASSACHUSETTS
QUABOAG RIVER

FLOODED AREAS

MARCH 1976

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
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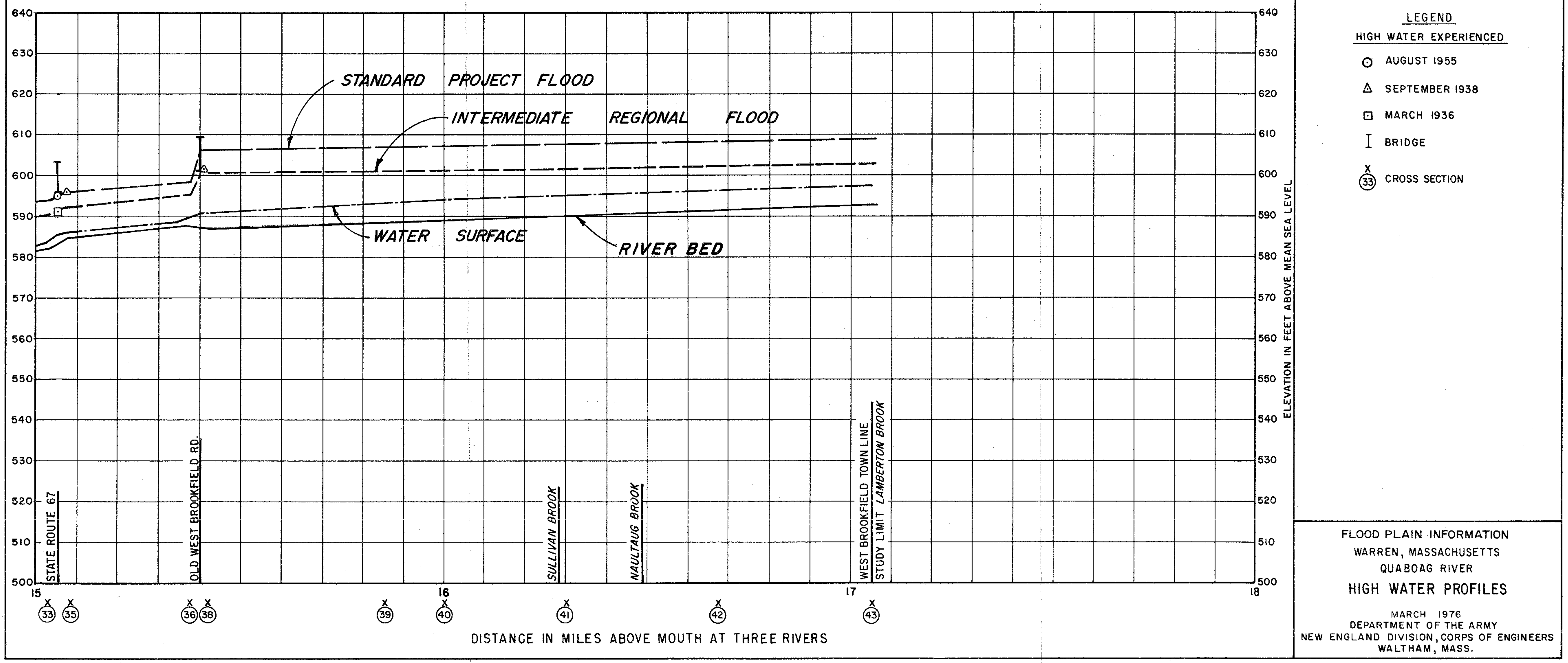

FLOOD PLAIN INFORMATION
WARREN, MASSACHUSETTS
QUABOAG RIVER

HIGH WATER PROFILES

MARCH 1976
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 8